Amend the following claim:

1. A piezoelectric actuator with

- a multilayered structure of piezoelectric layers (2) and electrodes (3, 4) disposed between them,
- an alternating lateral [contacting] contact (5, 6) of the electrodes (3, 4), wherein in the region between two piezoelectric layers, which contains one of the electrodes (3, 4) that are respectively contacted on opposite sides from one another, there is a neutral phase (7) without an electrode layer, and
- a shape of the multilayered structure which permits an increased mechanical stress to be exerted in the vicinity of the neutral phase (7) when the piezoelectric actuator (1) is clamped in place perpendicular to the layer structure.

Amended claim 1:

1. A piezoelectric actuator with

- a multilayered structure of piezoelectric layers (2) and electrodes (3, 4) disposed between them,
- an alternating lateral contact (5, 6) of the electrodes (3, 4), wherein in the region between two piezoelectric layers, which contains one of the electrodes (3, 4) that are respectively contacted on opposite sides from one another, there is a neutral phase (7) without an electrode layer, and
- a shape of the multilayered structure which permits an increased mechanical stress to be exerted in the vicinity of the neutral phase (7) when the piezoelectric actuator (1) is clamped in place perpendicular to the layer structure.

PRIOR ART

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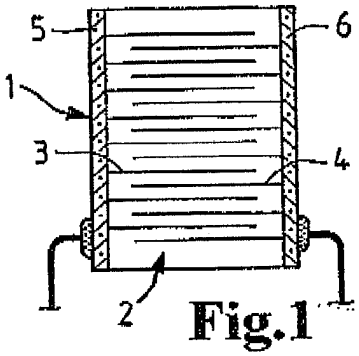

Fig.1

PRIOR ART

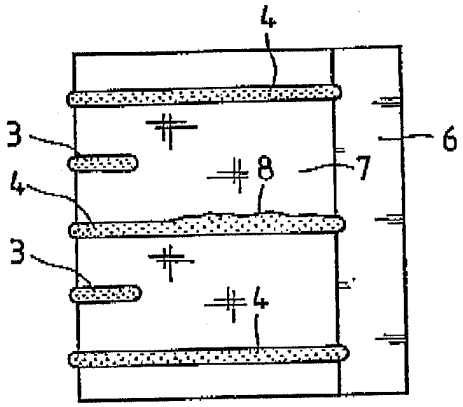

Fig.2

PRIOR ART

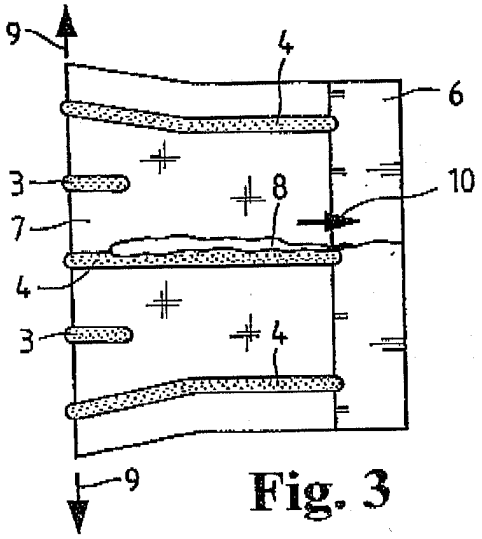

Fig. 3

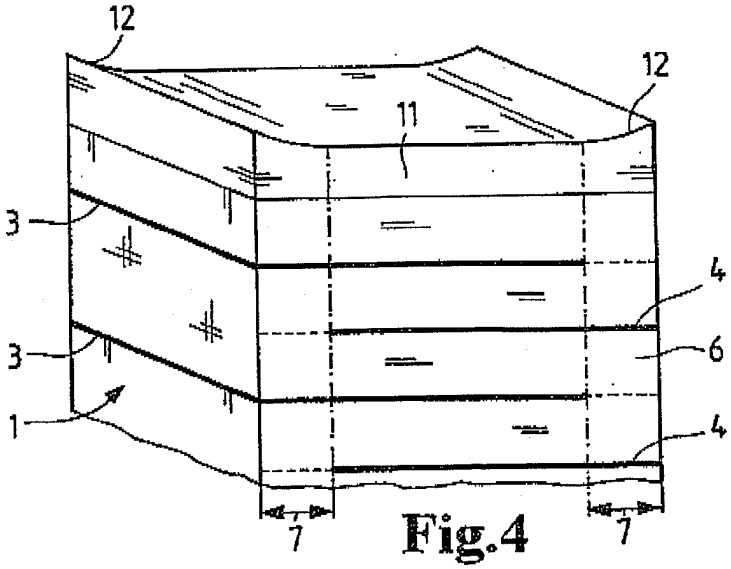

Fig.4

Piezoelectric Actuator

Prior Art

The invention relates to a piezoelectric actuator, for example for actuating a mechanical component such as a valve or the like, according to the features contained in the preamble to the main claim.

It is generally known that using the so-called piezoelectric effect, a piezoelectric element can be constructed out of a material with a suitable crystalline structure. The application of an external electrical voltage causes a mechanical reaction of the piezoelectric element which, depending on the crystalline structure and the region to which the electric voltage is applied, produces a compression or tension in a predictable direction. This piezoelectric actuator can be constructed of a number of layers (multilayered actuators), wherein the electrodes via which the electrical voltage is applied are respectively disposed between the layers. During operation of the piezoelectric actuator, care must be taken that mechanical stresses in the layer structure do not cause undesirable fractures to form.

Advantages of the Invention

The piezoelectric actuator described at the beginning, which can be used, for example, to actuate a mechanical component, is advantageously designed with a multilayered structure of piezoelectric layers with electrodes disposed between them. With a contacting of the electrodes on alternating sides, a neutral phase is produced in the region between every pair of piezoelectric layers . Since the electrodes, which are each contacted on one side, are integrated into the layer structure in comb fashion, the electrodes disposed one after another in the direction of the layer structure must respectively contacted in an alternating fashion on opposite sides from one another.

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The electrodes contacted on one side cannot extend all the way to the opposite side since otherwise, voltage arc-overs can destroy the piezoelectric actuator. When the piezoelectric actuator si actuated, i.e. when a voltage is applied between the electrodes on opposite sides in the layer structure, different mechanical forces are produced in the vicinity of the electrodes as well as in the non-contacted neutral phases, which can lead to mechanical stresses and fracture formation in the piezoelectric actuator.

According to the invention, when the piezoelectric actuator is clamped in place perpendicular to the layer structure, with a shape of the

multilayered structure, an intentionally increased mechanical stress is advantageously exerted in the vicinity of the neutral phases in order to prevent fracture formation.

In a first advantageous embodiment, at least one outer cover layer of the multilayered structure on the outer end face is embodied so that it has a thickening in the vicinity of the neutral phases and thus permits an increased initial stressing force to be intentionally exerted here. The thickening can be produced in a simple manner, for example by means of grinding the cover layer.

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In another advantageous embodiment, an insulating layer is disposed between the layers of the multilayered structure and this insulating layer has a thickening in the vicinity of the respective neutral phases and therefore functions in a comparable fashion to the first exemplary embodiment.

Another embodiment advantageously has especially embodied electrodes in the multilayered structure, which likewise have a thickening in the vicinity of the respective neutral phases, wherein with regard to the

various embodiments mentioned above, some or all of the features may be combined with one another.

These and other features of preferred modifications of the invention ensue not only from the claims but also from the specification and the drawings, wherein the individual features can be respectively realized singly or multiply in the form of sub-combinations in the embodiment of the invention and in other areas and can represent advantageous and intrinsically patentable embodiments which are claimed herein.

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Drawings

Exemplary embodiments of the piezoelectric actuator according to the invention will be explained in conjunction with the drawings.

Fig. 1 is a section through a piezoelectric actuator with a multilayered structure of electrodes and piezoelectric ceramic layers;

Fig. 2 is a detailed section through the layer structure in the vicinity of the neutral phases, without the application of an electrical voltage.

Fig. 3 is a detailed section through the layer structure in the vicinity of the neutral phases, with the application of an electrical voltage;

Fig. 4 shows a first exemplary embodiment of a piezoelectric actuator in which an outer cover layer has thickenings on the side surfaces, in the vicinity of the neutral phases;

Fig. 5 shows a second exemplary embodiment of a piezoelectric actuator in which an outer cover layer has thickenings on the side surfaces, in the vicinity of the neutral phases;

Fig. 6 shows a third exemplary embodiment of a piezoelectric actuator in which the electrodes have thickenings in the vicinity of the neutral phases; and

Fig. 7 shows a fourth exemplary embodiment of a piezoelectric actuator in which an insulating layer is disposed between the layers and has thickenings on the side surfaces, in the vicinity of the neutral phases.

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Description of the Exemplary Embodiments

Fig. 1 shows a piezoelectric actuator 1 which is comprised in an intrinsically known manner of piezoelectric foils 2 of a quartz material with a suitable crystalline structure so that that using the so-called piezoelectric effect, the application of an external electrical voltage to electrodes 3 and 4 via contact surfaces 5 and 6 causes a mechanical reaction of the piezoelectric actuator 1.

Fig. 2 depicts an enlarged region of the piezoelectric actuator 1 in which the electrodes 3 and 4 are shown, wherein the contacting of the electrodes 4 with the contact surface 6 is also shown here. Since the electrodes 3, due the different polarity, must be kept spaced apart from this contact surface 6, neutral phases are produced here which are shown by way of example in the form of the neutral phase 7. Due to the therefore spatially different occurrence of the piezoelectric effect, mechanical stresses are produced in the neutral phase 7 causing damage to the material, which is schematically depicted with the wavy line 8.

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Fig. 3 shows the region from Fig. 2, with the application of an electrical current, wherein the mechanical reaction of the piezoelectric actuator caused by this is indicated with arrows 9 and 10. It is clear here that in the vicinity of the neutral phase 7, less of an expansion in the direction of the arrows 9 is produced and therefore an exertion of force is produced in the direction of the arrow 10, which leads to a fracture formation in the vicinity 8 of the neutral phase.

A first exemplary embodiment of the invention will be explained in conjunction with Fig. 4, in which an outer cover layer 11 is disposed on the multilayered structure and is provided with a thickening 12 in the vicinity of

the neutral phases 7, which in the outer maximum can reach an order of magnitude of 2 to 8 µm. When the piezoelectric actuator 1 is clamped in place, this thickening 12 permits an initial stress to be exerted in the vicinity of the neutral phases 7, which prevents the fracture formation in the vicinity 8 of the electrodes 3 and 4 (see Fig. 3).

Fig. 5 shows a second exemplary embodiment which has an outer cover layer 11 with thickenings 13 which are disposed at opposite corners of the piezoelectric actuator 1. T he neutral phases 7 here are likewise embodied at the corners since in this exemplary embodiment, the contact of the electrodes 3 and 4 takes place via a contact surface 14 attached to the outer corner and a contact surface diagonally opposite from it, which is not shown.

In the exemplary embodiment according to Fig. 6, a thickening is produced in the vicinity of the neutral phases 7 by means of a local thickening of the electrodes 3 and 4 exclusively in the vicinity of the neutral phases 7.

Another exemplary embodiment according to Fig. 7 has a piezoelectric actuator 1 in which an insulating layer 15 that is extra-thick here

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is inserted between the piezoelectric layers 2 in the vicinity of the neutral phases 7 in order, when the piezoelectric actuator 1 is clamped in place, to exert an initial stress here as well, which prevents a fracture formation.

CLAIMS

1. A piezoelectric actuator with

- a multilayered structure of piezoelectric layers (2) and electrodes (3, 4) disposed between them,
- an alternating lateral contacting (5, 6) of the electrodes (3, 4), wherein in the region between the two piezoelectric layers, which contains one of the electrodes (3, 4) that are respectively contacted on opposite sides from one another, there is a neutral phase (7) without an electrode layer, and
- a shape of the multilayered structure which permits an increased mechanical stress to be exerted in the vicinity of the neutral phases (7) when the piezoelectric actuator (1) is clamped in place perpendicular to the layer structure.

2. The piezoelectric actuator according to claim 1, characterized in that

- at least one outer cover layer (11) of the multilayered structure on the outer end face is embodied so that it has a thickening (12; 13) in the vicinity of the neutral phases (7).

B3 cont.

3. The piezoelectric actuator according to claim 2, characterized in that

- the thickening (12) is disposed on opposite sides of the cover layer (11), in accordance with the placement of the neutral phases (7).

4. The piezoelectric actuator according to claim 2, characterized in that

- the thickening (13) is disposed at diagonally opposite corners of the cover layer (11), in accordance with the placement of the neutral phases (7).

5. The piezoelectric actuator according to one of claims 2 to 4, characterized in that

- the thickening is produced by grinding the cover layer.

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6. The piezoelectric actuator according to claim 1, characterized in that

- an insulating layer (15) is disposed between (some or all?) Of the layers of the multilayered structure and has a thickening in the vicinity of the respective neutral phases (7).

7. The piezoelectric actuator according to claim 1, characterized in that

- the electrodes (3, 4) of the multilayered structure each have a thickening in the vicinity of the respective neutral phases (7).

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8. The piezoelectric actuator according to one of claims 2 to 7, characterized in that

- some or all of the features of these claims are combined with one another.